

Estimates of Construction for Stage One development of the land of Siga^[IMC]

Brief:

The nation is expected to support an initial population of 1500 citizens for the functions of the state and laboratory for which the nation was founded. The final population is expected to eclipse 30,000 citizens at 'maximum capacity'. The costs listed below represent the development and construction of residences, the laboratory and civic buildings to support the 1500 citizens.

Some costs are calculated to meet the proposed maximum capacity in cases where it is more feasible, cost-effective or rational to build said buildings and infrastructure in a single effort rather than expanding them in stages. Examples would be subterranean infrastructure, roads, land preparation and so forth.

Foreword on Estimates:

All costs will supply or cite sources to peg their value. For the sake of completeness, whenever a range of expense is supplied by a source, and I am unable to reasonably define the exact cost by the supplied variables and outlines, the cost will be set to the highest applicable value listed. This method, which may inflate some expected costs, helps to ensure that the estimates are not undervalued and helps to prevent the cost running over expectations.

Due to the sparsity of sources in certain categories, such as large scale infrastructure costs, in which I can only ascertain a singular data point it will be denoted with a marker. This will help to identify when data and costs are 'isolated' (subject to market trends, regional manpower and materials costs). The location of the city within the Balkan region of Europe we can be expected that costs of materials will be markedly different from that of a highly industrialised county such as the USA or Japan; As such, although the estimates provided by the cited sources will be retained, it can be reasonably expected for the city to be constructed at a reduced cost.

Cost conversions:

Dependant on the source different currencies will be used however the final cost provided in **RED** will always be in USD. This is subject to changes as the ratio between the USD and domestic currency will change over time. The calculations were made in April 2024.

Capital costs of Construction

Land Preparation:

In order to adequately support the construction of structures a stable location must be created. The land will be elevated to reinforce the ground with layers of suitable aggregates and a flood wall will be installed to prevent erosion by the adjacent Danube river. **The size of Siga is 6km².**

Terraforming – Levelling and raising the land to be two metres above the waterline will require 12km³ of fill (plus another 3km² due to compaction and as a safety net) for a total of 15km³. Given that a cubic metre of dirt weighs approximately 1.5 tonnes^[1], the total required tonnage of soil would be 22500 tonnes. Sandy loam at a cost of \$29 USD per tonne^[2] the total cost would be **\$0.65 million USD** (not including labour).

Flood wall – Designed as a cantilever retention wall constructed of stone the flood wall will skirt the entirety of the landmass. The 12.5km circumference of the land, requiring a 2 metre high wall is estimated to be approximately \$360-390 USD p/m^{2[3][4]} for a total cost of **\$9.73 million USD**.

Total Cost: \$10.58 Million USD + Labour

Roads:

The city is designed to be highly walkable with emphasis on bicycle and tram infrastructure. Approximately, only a third of all roads will be conventional sealed roads for motor vehicles, with the remainder as paved roads composed of setts or flagstones. Using Singapore as an estimate as to the required km of road needed per km², we can speculate that there may be as much as 500km/km^{2[5]}, resulting in a total of 3000km of roadways.

Sealed roads – Source 6 estimates that the cost per meter of a collector road laid is approximately \$1700 USD (as a base cost)^[6]. Given that one third of all roads will be comprised of conventional sealed roads then the 1000km of road required would cost \$167.1 Million USD. Due to the added complexities of integrating bicycle and tram infrastructure the cost will be increased by 20% as a safety measure, for a total cost of **\$200.5 million USD**.

Paved roads – The cost of roads paved with cobble / setts / flagstones vary greatly depending on the material required. Prices range from 100 to 265 USD^{[7][8]} per metre squared for suitable materials. Should we consider the upper limit across 2000km of road with a width of 6 meters it would cost 3.18 Million USD. Additional costs such as integration with manholes and water run-off infrastructure will increase its value by a further 20% for a total cost of **\$3.8 million USD**.

Total Cost: \$204.3 Million USD

Subterranean Infrastructure:

All infrastructure will be concealed in maintenance shafts tracing the roadways. This land may be demarcated before the land preparations to accommodate the required trench works. This will be built in combination with the roads in a singular effort reducing excessive planning. It is planned that this infrastructure be compliant with the neighbouring countries to accommodate external connections. Electricity wattage and voltage and pipe diameter are to be standardised.

Tunnels – We are afforded of the privilege of using the 'Cut-and-cover' system of construction greatly reducing the cost and time required to build the utility tunnels. Considering the cost of the "Dartford Cable Tunnel" constructed in 2004, the 2.4km tunnel cost \$26.1 million USD^[10] (adjusted for inflation) at \$10.88 million per km. If said tunnels are to be placed under the 20km long tramways then we can estimate the cost to be **\$217.5 million USD**, though due to the simplicity of the terrain it is expected to cost less.

Water – A report provided by the region of Ontario, Canada^[11] calculates the replacement cost of their water infrastructure (Potable, waste and storm waters) to be valued at \$167.6 billion USD across their 50,000km pipeline network. Given that the cities of Ottawa and Toronto are the only two notable settlements of the region stretching over a 12,672km area collectively. This would indicate that per square kilometre of land occupied it requires 4km of pipeline on average. Taking the cost of infrastructure and size of Siga^[IMC] it would require 24km of pipeline costing **\$80 Million USD**.

Electricity – Dependant if the electrical infrastructure is above or below ground the estimated cost varies greatly. Costs ranging from \$0.2-1.5 million USD^{[12][13]} per kilometre for such infrastructure, with the upper values representing the more costly underground variant. If we consider the electrical grid paired with the other

subterranean infrastructure we will require 24km of cables costing up to **\$36 million USD**, not including supporting terminals and equipment.

Pneumatic - Scarce information on the subject yields few projects utilising pneumatic waste collection systems that list their capital costs. Using a case study^[14] and research papers on the subject^[15], then extrapolating the estimates and pairing it to the requirements of Siga^[IMC], the costs would be as high as **\$424.8 million USD**.

NOTE - *Some of the costs associated with the various forms of infrastructure will be covered by the construction of the tunnels. As such this estimate may be greatly reduced.*

Total Cost: \$758.3 Million USD

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Mixed-use apartments:

All housing located in the city will be uniform in role (but not in architecture) to accommodate the population. Apartment buildings will support a business on the lower floor, and 2-3 upper storeys for residences.

Base Costs – European and American estimates are equivalent with the standard 2 bedroom apartment costing approximately \$0.23 million USD per unit^{[16][17]}. The apartments will also be furnished with another \$0.07 million dollars worth of assets rounding the average cost per apartment to be \$0.3 million USD. If all buildings are to be four total floors (including the ground floor) and that the lowest floor is designated as a business, each apartment building houses 3-6 citizens. Given that the initial population required will be 1500 with a 60% occupancy rate there will need to be 1700 'spaces' across 425 4-storey buildings (including businesses) occupying 0.4km². Based on this we can estimate the base cost for the mixed-use apartments would be **\$510 Million USD**.

PassivHaus design – As a measure to reduce energy waste all dwellings are to be constructed in line with the 'PassivHaus' standards of construction. The average increase in designing by these standards increases the overall cost of **3-15%**^{[18][19]}. This ensures and ongoing reduction in heating costs by 7%^[19], reducing upkeep overall.

Architecture – Due to the nuances covered in the architecture documentation elsewhere, a value must be ascribed to the non-standard external design of the buildings. Frontages, ornate designs, cladding, etc, will incur costs not exceeding **15%** of the building's base cost.

Total Cost: \$663 Million USD (Maximum)

Civic and Public Buildings:

Providing the necessary emergency services is essential at all points of construction, not only for the citizenry but also to provide protections to those working on site. Due to the expected size and scale of the governmental structures buildings such as the state museum act as a gathering point for the population whilst other structures are being built.

Governmental structures –

Parliament:

Costs vary greatly dependant on designs. Australia's Parliament is estimated to be \$3.2 billion USD and India's new parliament is said to be valued around \$100 million USD. Between engineering, material and labour costs, etc, it can be any value. A placeholder value will be set at **\$200 million USD**.

Courthouse:

Essential at the formation of the state. Other than housing the judiciary it will need to support the fledgling lawmaking period. The Australian High Court's construction is estimated at \$152 million USD^[20] (adjusted for inflation) whereas the USA's Supreme court is valued at \$215 million USD^[21] (adjusted for inflation). A placeholder value will be set at **\$200 million USD**.

Museums and Education –

State museum:

As with the governmental structures prices vary greatly dependant on purpose, size and design. Comparative examples include the 'Museum of London' at \$419 million USD^[22] to the 'Paramatta Powerhouse museum' in Australia valued at \$354 million USD^[23]. A placeholder value will be set at **\$300 million USD**.

State School:

Unlike the majority of essential constructions, the school may be built initially to accommodate the students at the formation of the city and expanded when necessary; As such the values will be dependant on the estimated 500 student present at foundation. Example ranges for schools include North Carolina [USA] at \$1498 – 3050 p/m²^[24], Virginia [USA] at \$3616 – 5575 p/m²^[25], or European estimates of \$4838 p/m² or as much as \$55163 per student^[26]. Considering these evaluations should we consider the latter most cost multiplied by the 500 student body it would cost **\$27.5 Million USD**.

Banking and Finance –

Central Bank:

The central bank of Pannonia serves to monitor the state's assets, be the sole chequing and clearing bank and to provide tangible money notes. It does not seek to directly interact with the public outside of the ATMs supplied nor does it

store gold supplies. Due to its nature the costs will not be as great as other central banks. Costs range from Australia's Reserve bank at \$103 million USD^[27] (adjusted for inflation) to the European Central Bank at \$1.5 billion USD^[28]. Due to its diminutive size and narrow spectrum of tasks. A placeholder value will be set at **\$100 million USD**.

Public services –

Fire:

Sources from the USA have costs ranging from \$5300 – 10070 p/m² ^{[29][30]} in buildings upwards of 10,000m² in size. Total costs likewise range from \$5 million to \$98 million USD. Although the size of the proposed nation is small it will have a singular fire station requiring it to be adequate for all scenarios (chemical / rescue / water tanks / etc.) As such a placeholder value will be set at **\$100 million USD**. Emphasis is put on supplementing manpower with technology.

Medical:

Unlike other buildings costs hospitals are projected not only by m² but also by a 'per bed' metric. The latter of which gives a more narrow objective as it correlates to a common 'beds per 100,000' statistic to compare nations. The majority of European nations, including those of the east, aim to have 5 beds per 100,000^[31]; This however would be unfeasible in a population under 40,000 as it results in 2 beds for the entire nation. The country will instead host a 100 bed hospital to support its needs. Costs per m² for 'smart hospitals' range from \$500-650 USD or alternatively \$0.5-1.5 million USD per bed^{[32][33]}. This would result in a price as high as **\$150 million USD**.

Police:

A design document by the International Associations of Chiefs of Police provides a spectrum of designs, considerations and estimated prices for the development of a police station. In the document we can observe prices of \$1969-2825 USD p/m² ^[34] for the given examples. As with the hospital, although it does not need to support a large population it does need the capabilities in order to overcome multiple challenges such as arrest, detainment, jailing, offices, etc. Considering this, and observing the examples provided in the document a budget of approximately **\$65 million USD** is appropriate (this includes a proposed 10 'Koban' style police outposts around the city).

Parks:

Information about park construction is scarce as the majority of costs incurred are due to land purchasing, otherwise are so old that they are inherited by a modern state at no cost with subsequent upgrades unlisted or lost to time. Should we consider that a third of all land be green spaces (inline with Copenhagen) then approximately 2km² will be required for parks (upper estimate). A notable urban park is New York's Central park valued at \$242 million USD^[35] or \$70 USD p/m². Using this as a baseline park development costs may cost **\$140 million USD**.

Total Cost: \$1282.5 Million USD

Laboratory:

The core component to the city, the laboratory should be designed to suit the staff allocated to it and be able to be expanded to meet population / workforce growth. The costs covered in the 'stage one development' is expected to only be a fraction of the costs of the planned expansions.

Costs:

A conventional laboratory structure is composed of two main components, the laboratory facilities and the offices for staff. The former comes in the form of a Class 2 medical lab which is estimated to cost \$3000 – 5700 USD p/m² ^{[36][37]}. The office construction costs can range from \$3400 – 5600 USD p/m² ^{[38][39]} based on European standards. The initial workforce of 500 staff will receive 10m² of office space and 20m² of lab space per person. This results in an office occupying 5,000m² and a lab occupying 10,000m². Costing (at the highest values listed) **\$28 million USD** and **\$57 million USD** respectively. An additional **\$20 million USD** will be added to represent increased automation and machinery.

In comparison the "University of Basel's Department of Bio-medicine" in Switzerland was set to cost \$275 million USD for a 37,000m² lab^[40] resulting in a cost of \$7432 USD p/m².

Total Cost: \$105 Million USD

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Communications / Logistics:

Data centre(s):

The standard European data centre is valued at \$14 million per megawatt ^[41]. To correlate power consumption with data use we can find a conversion of 5.12 kWh p/GB^[42] Should we estimate that the average person uses 1TB a month or 33.3 GB daily, over a population of 2000 (additions made to compensate for research demands), would mean supplying 66TB of data daily. Knowing that, the estimated power draw would be 338,000kWh or 14.1 Megawatts at any given time. This would require a **\$198 Million USD** data centre which may be decentralised into smaller, self-contained centres on-site (to secure research data).

Note: Ensure that the data centre uses '*waterside free cooling*' to reduce energy demands and potentially connect heat output into district heating elements.

Customs, Mail and Freight Distribution:

Located at the only entrance to the city this secure complex is broken into incoming, outgoing and freight / mail terminals. All traffic entering the nation passes through customs which requires facilities to support the efficient flow of goods. The area allocated to this complex will be 200,000 m² with a 2km circumference. In order to prevent unlawful / forceful entry a 3 metre high and 3 metres wide earthwork will be present. When using the information covered in the 'land preparation' section earlier, the total cost of this wall would be **\$5.5 million USD** (including twin retaining walls). The border customs building will be the largest component, accepting and observing vehicles. Dependant on the demand of crossings it will dictate the cost associated with construction. Examples of this varying spectrum include the 30,000 m² San Ysidro point of entry between the United States and Mexico costing \$625 million^[43] as of its recent redevelopment, to the small Cijevna – Gabron crossing between Albania and Montenegro valued at \$0.77 million USD^[44]. Due to the scarcity of information a speculative value will be set at **\$150 million USD**.

Adjoining to the customs area is a simplified goods drop-off point that serves as the mail and postage centre of the nation. Due to the historical nature of post offices the information of construction costs are scarce. Contemporary post offices are estimated to cost between \$328 – 570 p/m²^[45]. Considering that a the postage distribution centre will extend the customs boundary it will not be restricted in size; As such it will be allotted 2000m² for a building plus 500m² of additional space for a vehicle depot and loading zone. This will cost approximately **\$1.5 million USD**.

Total Cost: \$355 Million USD

Total Cost
\$3.379 Billion USD

Total Cost including safety net (20%)
\$4.054 Billion USD

OTHER CONSIDERATIONS:

This does not cover every construction that will be present in the nation. Some structures and services, notably the planned tram line, will cost up to \$2 Billion USD. This however may be delayed without significant problems arising but as the street layout is being designed it is essential that land be allocated and preserved for later construction. Forgoing this step would be costly and disastrous.

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